Fishery Data Series No. 91-49

Situk River Steelhead Studies, 1990

by

Robert E. Johnson

September 1991

Alaska Department of Fish and Game

Division of Sport Fish

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ABSTRACT

Recording fathometer (sonar) and visual observations were used to count the early portion of the spring steelhead *Oncorhynchus mykiss* immigration to the Situk River during 1990. The latter portion of the immigration run and all of the emigrant kelts were counted using a weir.

Most upstream movement by steelhead occurred during periods of darkness. Barrier structures were used to constrain steelhead passage into an ensonified channel approximately 10.5 m (35 ft) wide. There were periods when incorrect sonar settings and transducer aim, or environmental conditions, caused poor correlation between observed and sonar counts. This correlation improved during the season until 88% of the steelhead observed passing the site during 60 hours of simultaneous counts at the peak of immigration were recorded by the sonar.

The estimated total count of immigrant spring steelhead (sum of visual, sonar, and weir) was 3,024 steelhead. The estimated minimum total number of spring and fall run steelhead emigrating from the river in 1990 is 3,882 fish (sum of downstream kelt count, mortalities at the weir, and harvest estimate). Sonar is a viable tool for estimating the immigration of steelhead into the Situk River.

KEY WORDS: steelhead, *Oncorhynchus mykiss*, sonar enumeration, transducer aim, barrier structures, escapement, Situk River, Yakutat, Southeast Alaska

INTRODUCTION

The Situk River, located on the Gulf of Alaska near Yakutat (Figure 1) contains the largest known steelhead *Oncorhynchus mykiss* population in Southeast Alaska. The Situk River is 35.2 km (22 mi) long, and has two lakes in its headwaters that have a combined surface area of approximately 397 hectares (992 acres).

Adult steelhead enter the Situk River during August-December (fall run), and during March-June (spring run). Fall-run spawning coincides with the return of the spring run of fish to the Situk River. Spawning has occasionally been observed to begin as early as February (fall-run fish), but most steelhead spawn from early May through mid-June. It is not known whether the spring and fall runs interbreed. Jones (1983) reported that approximately 25% of steelhead returning to the Situk River in 1982 had spawned previously, and that some fish returned to spawn as many as four times. Juvenile steelhead reared for two to five years in fresh water, and for one to three years in the ocean before returning to spawn; the dominant age class (32.4%) in 1982 was 3.2 (Jones 1983).

Between 20,000 to 26,000 post-spawn steelhead (kelts) were counted down through the Situk River weir in 1952 (Knapp 1952). Recent estimates of the size of the Situk River steelhead population have been substantially lower. During the spring of 1990, 3,630 steelhead emigrated through the ADFG Division of Commercial Fisheries weir on the lower Situk River.

The Situk River supports a popular spring steelhead fishery and a developing fall steelhead fishery. Angler effort during the spring fishery has ranged from 10,434 to 16,379 hours from 1985 through 1990 (Table 1). Anglers harvested from 287 to 423 steelhead annually during that period and released from 1,139 to 4,991 fish. Johnson and Marshall (*In press*) estimated the total 1990 effort for steelhead at 15,661 angler hours and the catch (kept plus released) at 1,460 steelhead. Estimated angler effort during the spring of 1990 was 19% higher than the previous 5-year average. The estimated steelhead catch was about half the average for the same period. Peak angling effort occurred between April 21 and May 6.

Apparent declines in recent catches and concern about escapement is renewing interest in steelhead population assessments in the Situk River. A weir provides an accurate count of the steelhead immigration, but it can also delay the run, increase steelhead mortality through predation by both terrestrial and aquatic mammals, and disrupt boat traffic during the sport fishery. Visual counts would not disrupt the immigration or boat traffic, but would be useless during periods of poor visibility and would require that personnel be stationed at the site and remain attentive for long periods of time. Sonar counters have none of these disadvantages. Further, the use of recording fathometers (commonly found on fishing vessels) to count steelhead would be substantially less expensive than purchasing sonar units constructed specifically for this purpose.

In order to use a recording fathometer (sonar) to count steelhead on the Situk River, several initial conditions must be met (David Gaudet, Alaska Department of Fish and Game, Douglas, personal communication). These conditions are:

1. Only one species (steelhead) may be present at the time of counting;

2. The total run must not be too large (<10,000) so there is a reasonable chance that targets will be separated spatially;

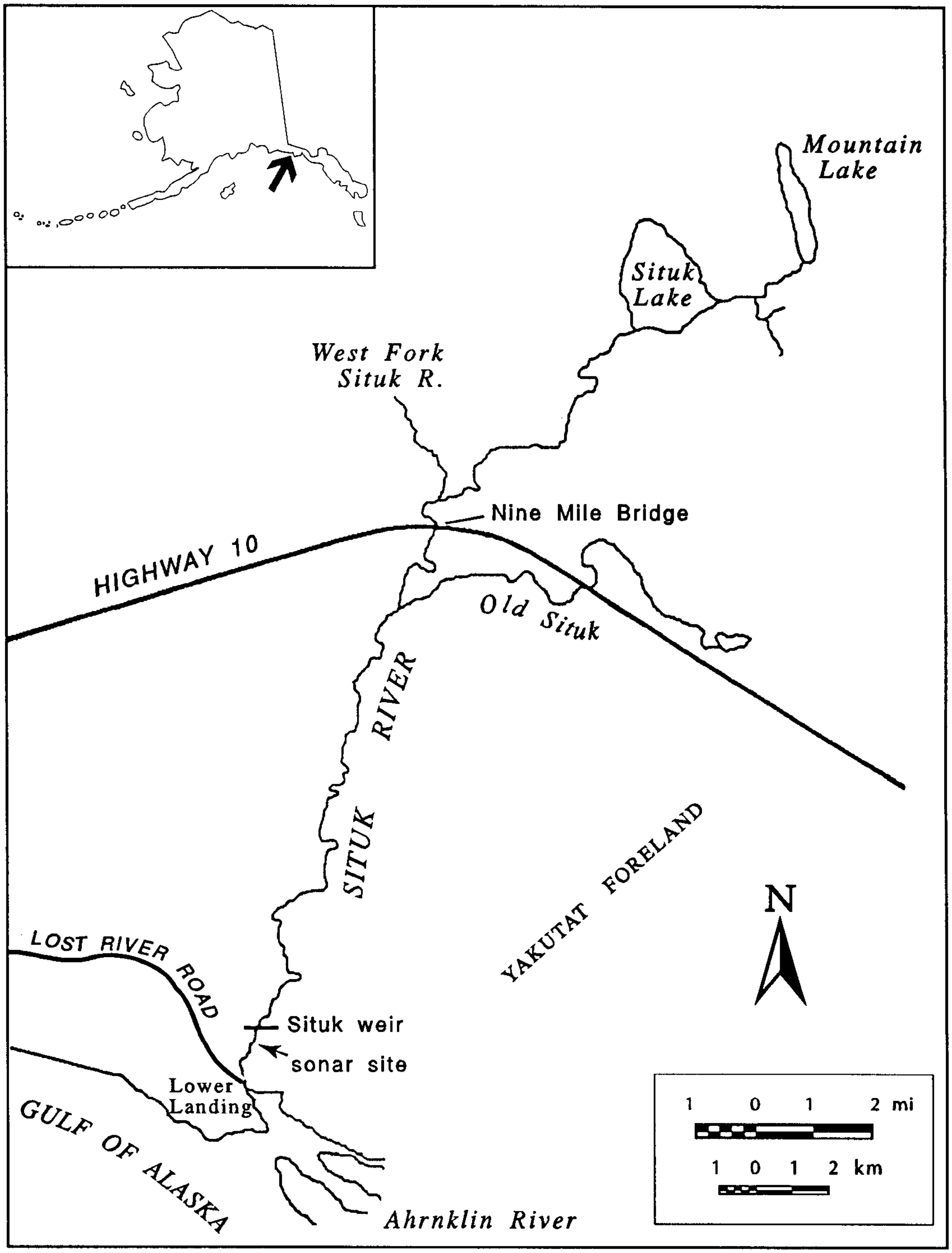

Figure 1. Situk River system, northern Southeast Alaska.

Table 1. Estimated angling effort, steelhead harvest and release during the spring Situk River sport fishery, 1985-1990.

Year	Effort	Steelhead		CPUE	Ratio released to kept
		Kept	Released		
1985[a]	10,434	362	2,695	0.29	7.4
1986[b]	12,283	287	2,094	0.19	7.3
1987[c]	10,542	391	3,797	0.40	9.7
1988[d]	16,379	423	4,991	0.33	11.8
1989[e]	12,953	361	2,055	0.19	5.7
1990[e]	15,661	321	1,319	0.09	3.5
1985-89 Mean	15,518	365	3,126	0.28	8.4

[a] Mecum and Suchanek (1986). Survey missed the early part of the run; informal surveys indicated that at least 2,230 hours of effort were expended to harvest 66 steelhead and release another 1,889 steelhead between 4/15 and 4/29.
[b] Mecum and Suchanek (1987).
[c] Bingham, Suchanek, Sonnichsen, and Mecum (1988).
[d] Suchanek and Bingham (1989).
[e] Johnson and Marshall (*In press*).

3. Steelhead must not use the prospective counting site as a holding area;

4. The counting site must be narrow and shallow (<19.5 m [65 ft.] wide and ≤1 m [4 ft] deep);

5. The location must be acoustically quiet.

6. The water must be clear enough to observe fish so that counts may be verified;

7. The bottom must be composed of fine substrate.

Such a site was located, and this study comprises the second year of a 2-year program to count the spring run of steelhead returning to the Situk River. The first season of this project demonstrated that recording fathometers could be used to count steelhead accurately under controlled conditions (Johnson 1990). The objectives during this second season were to continue developing the methodology to count steelhead by sonar, visually, or by a combination of both methods, until the installation of the ADFG Division of Commercial Fisheries weir to count sockeye *O. nerka* salmon.

Another task during 1990 was to track the movements of fall run steelhead through radio-tags. The purpose of this feasibility study was to determine where steelhead spent the winter and when they moved into spawning areas. This information enabled installation of the weir late enough to allow an uninterrupted spring immigration but early enough to provide an accurate count of the fall and spring emigrant kelts.

METHODS

Study Location

The counting site described in Johnson (1990) was used again during 1990. The site was 2.4 km (1.5 mi) upstream from the Situk River Lower Landing and approximately 3.6 km (2.25 mi) upstream from the mouth of the Situk River (Figure 1). The width of the river at the site was about 19.5 m (65 ft), with low-water minimum and high-water maximum widths of approximately 15 and 24 m (50 and 80 ft), respectively. During average flows, the bottom contour gradually sloped to a depth of about 1 m (4 ft) on the eastern shore. Bottom substrate was composed of sand and small gravel. Tides above approximately 9.0 feet elevated water levels at the site; the water level rose approximately 5 cm (2 in.) on a 9-ft tide. Maximum tidal heights at the Situk River mouth are just over 11 ft.

The eastern shore of the river was a vertical sand and gravel bank about 2 m (8 ft) high, vegetated with climax spruce forest. The western shore of the river was a gravel bar, backed by a bank approximately 0.9 m (3 ft) high and vegetated with willow and alder. Camp was constructed on the eastern bank, offering a good view of the river and protection from high water conditions. The proximity of the camp to the river was constrained by the length of transducer cable available (45 m [150 ft]).

A 12-m-long (40-ft) barrier was constructed of aluminum channel, iron pipe, and three-quarter-inch conduit, supported by wooden tripods to concentrate steelhead along the deeper east side of the river channel and prevent fish from passing behind the transducer (Figure 2). The barrier extended downstream from the western shore at approximately 110°. A 7.2-m-long (24-ft) iron pipe, channel, and conduit "fence" was constructed along the eastern shore across from the barrier to restrict access by fish to brush and rootwads in that area. The unobstructed passage between the barrier and the fence was about 9 m (30 ft). Aiming the transducer at the 7.2-m "fence" also restricted the distance that the sonar beam traveled in the water. The "fence" section provided a regular surface to reflect the sonar beam, rather than allowing it to be reflected by the irregular slope of the opposite bank (Figures 3 and 4).

Sonar Counts

Two LOWRANCE X-16[1] recording fathometers with 8° (narrow beam) transducers were mounted in the tent frame. Each fathometer contained a microcomputer that could be programmed to perform electronic filtration of noise, depth range, paper speed, sensitivity, and pulse length. These functions were retained while the power was turned off, allowing automatic start-up from a preprogrammed machine. The equipment was powered by a 12-volt deep-cycle lead cell battery; a full charge provided power for approximately five days of continuous operation. Targets detected by the sonar were recorded on paper rolls 15 m (50 ft) long by 10 cm (4 in.) wide. Paper speed was programmed by the operator, allowing about 6 hours of operation per roll. Sonar recorders were controlled by a sequential timer; a marker in the timer created a one-eighth-inch blank space on the graph each half-hour. The condition of the battery was also monitored by a meter in the timer.

The sonar transducer was equipped with a 45 m (150 ft) cable to which a resistor had been added near the sonar connection to compensate for the cable length. The transducer cable ran from the transducer aimer in the river to the recording fathometers that were mounted inside the tent. The beam spread of the transducer was plotted by physically floating targets through the beam and marking the river bottom with stakes, or by calculating the spread based on the nominal beam width of the transducer at a particular transducer depth and projected distance. The approximate beam spread (W) of each transducer at distance (D) was estimated as $W=2D\tan(\theta/2)$, where θ was the beam angle of the transducer. The effective distance of ensonification was the greatest distance at which the beam width matched the depth of the stream. Since the sonar in this installation projected the sonar beam horizontally through the water column, the depth designations on the graph recording represented horizontal distance from the transducer.

A triangular transducer aimer, weighing approximately 45 kg (100 lb), was constructed from iron channel (Figure 5). The aimer was 1.2 m (4 ft) high and approximately 1 m (4 ft) long on each side. The transducer was mounted on the end of a horizontal rod that was suspended from a crossbar between two corners of the frame; the cross bar had been modified from that described in Johnson (1990) to allow stepless depth adjustments for the height of the aimer. Vertical aim could be adjusted between -40° and +30° of horizontal with a mechanical hand crank at the third corner. Aim was adjusted laterally by pivoting the entire aimer or by sliding the transducer mounting bar along the horizontal cross bar.

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[1] Reference to trade names does not imply endorsement of the product by the Alaska Department of Fish and Game.

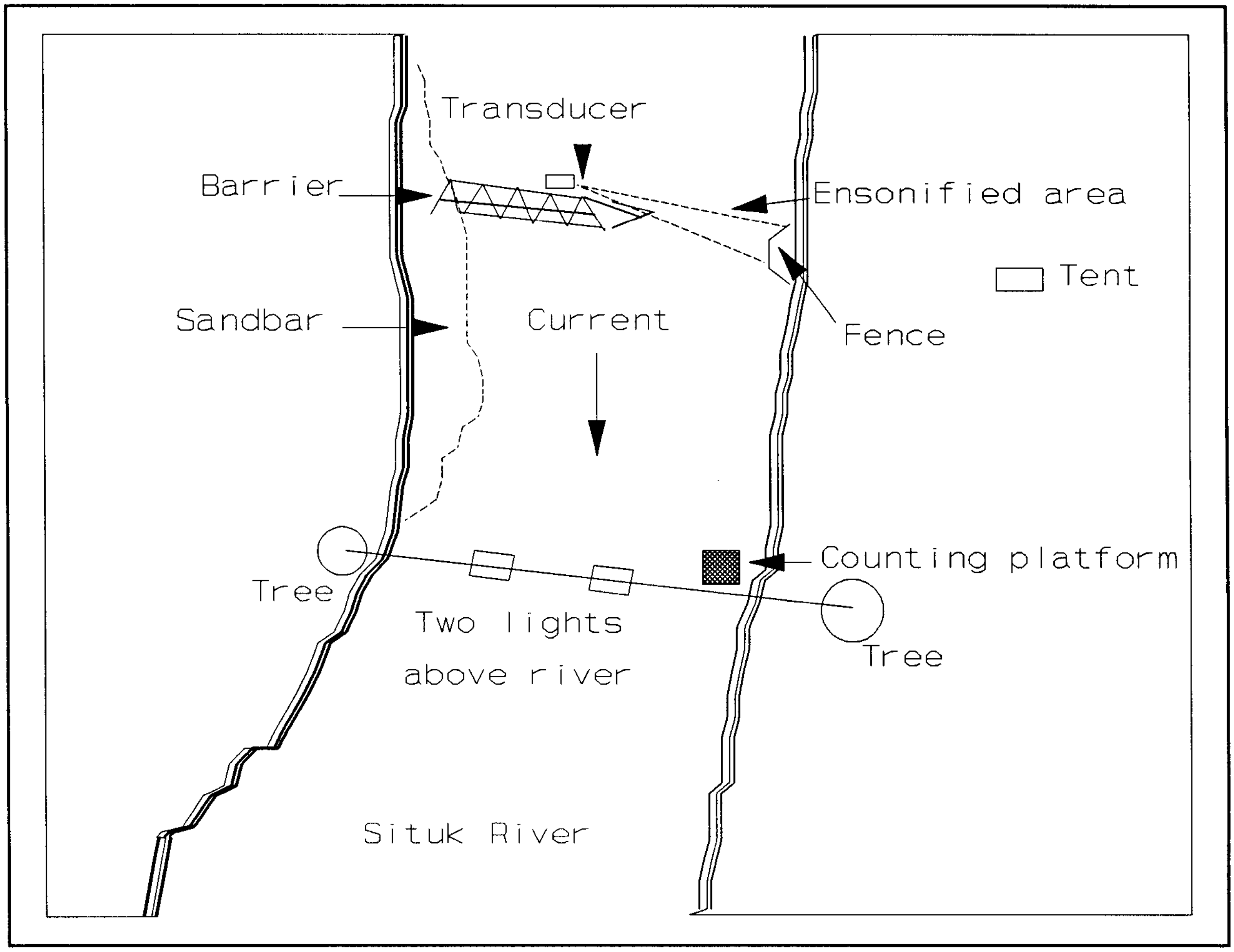

Figure 2. Initial configuration used while counting steelhead with sonar at the Situk River, 1990.

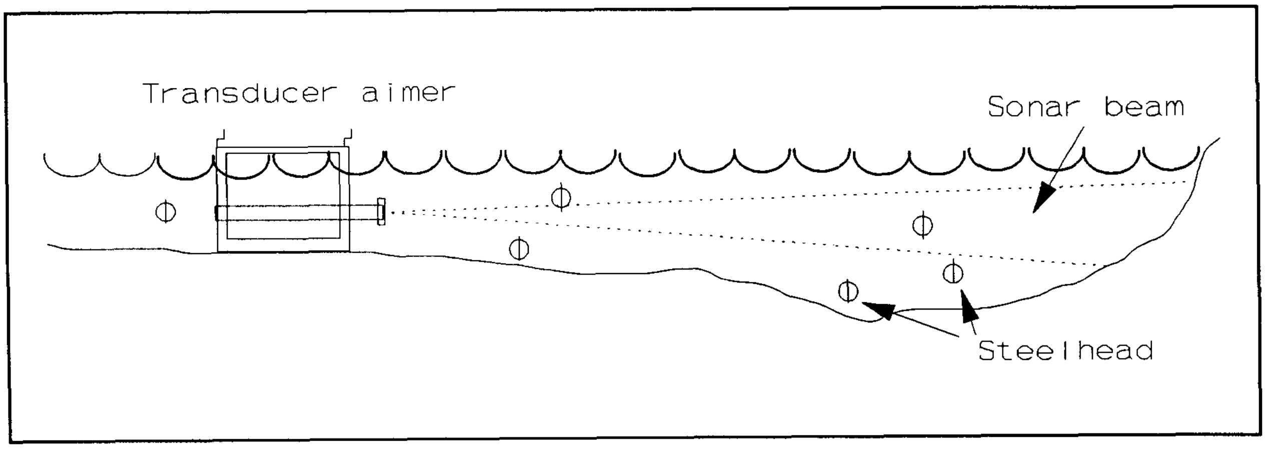

Figure 3. Problems that were encountered with the sonar in an improper configuration without in-water structures.

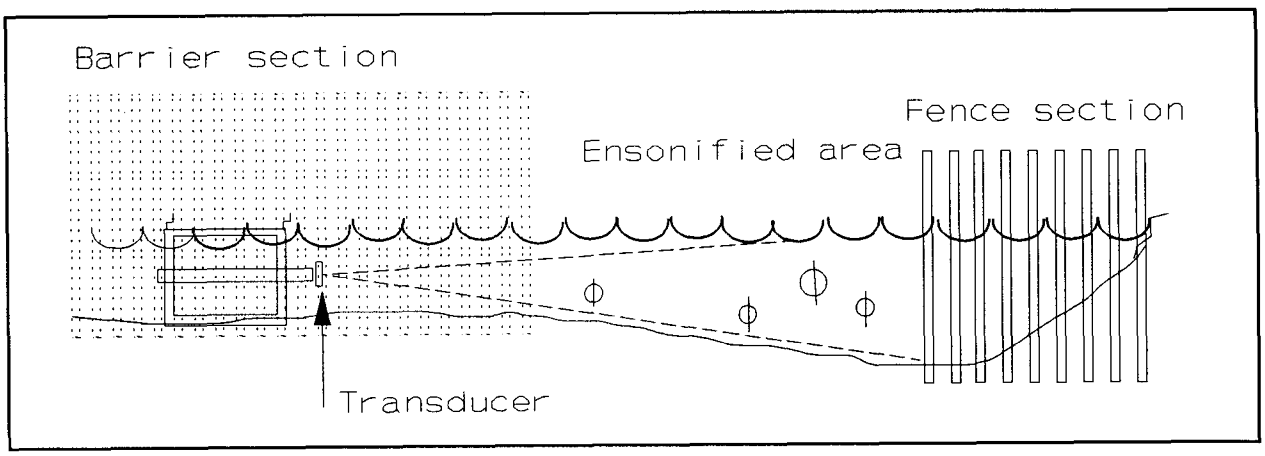

Figure 4. Proper configuration of the sonar transducer and associated structures.

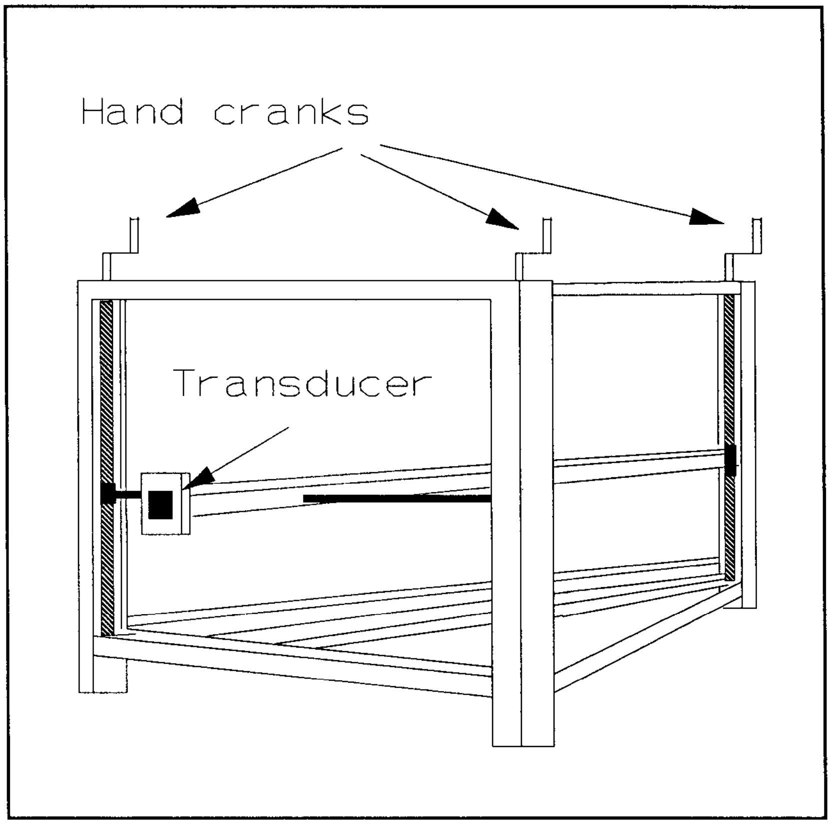

Figure 5. Transducer aiming device used on the Situk River during 1990.

The transducer was positioned on the upstream face of the 12-m (40-foot) barrier section, approximately 5 m (16 ft) from the midstream end (Figures 2 and 4). The distance that the transducer was set back from the end of the deep water barrier section was determined by matching the calculated beam spread with the depth of the water at the end of the barrier section (Figure 4). The transducer was located in water 76-102 cm (30-40 in.) deep, positioned halfway between the bottom and the surface, and aimed one or two degrees toward the surface and about 105° downstream.

Adjustable controls on the LOWRANCE X-16 included sensitivity (gain), grayline, discrimination, paper speed, range, lower limit, upper limit, surface clarity control, suppression, alternate transmit and print, and pulse length. The optimal control settings were generally as described in Johnson (1990). A proper recording showed a dark, defined bottom mark (at the correct depth [i.e., distance] setting), clearly marked debris or targets drifted through the sonar beam, and exhibited minimal banding caused by side lobe or improper aim.

Sonar counts were obtained by reviewing the paper sonar chart recording, and counting the number of upstream and downstream targets. Sonar counts were verified through correlation of simultaneous visual observation of the sonar chart recorder by one observer in the tent, and of fish travelling past the site by another observer in the counting platform. If the sonar was adjusted correctly, the targets appeared on the sonar recording after a brief time delay.

The delay was a function of the distance the steelhead traveled between the tower and the sonar beam.

Visual Counts

Visual counts were used to verify sonar counts, and to provide counts if the sonar was not operating properly. Visual counts were conducted each evening between 2000 and 0030 hours, and during daylight hours on incoming tides. An observer in a counting platform recorded the number of steelhead observed passing the site in either direction. The counting platform was located approximately 36 m (120 ft) downstream from the tent and approximately 18 m (60 ft) downstream from the 12-m (40-foot) barrier (Figure 2), as described in Johnson (1990). The platform was approximately 5 m (16 ft) high and overlooked a river channel that was approximately 1 m (4 ft) deep.

Both 300-watt and 500-watt broad-beam halogen floodlights provided illumination during periods of darkness. At the initial downstream counting platform location, one 300-watt and one 500-watt floodlight were deployed. The lights were suspended from a line stretched approximately 3.6 m (12 ft) above the surface of the river below the counting platform and were powered by a 1000-watt generator. Near the end of the study (April 24), the floodlights were moved about 135 m (150 yd) upstream of the sonar site (Figure 6) to minimize behavioral effects created by artificial illumination on nocturnally immigrating steelhead. The upstream site was used for evening counts, while the original downstream tower was used during daylight observations. One 500-watt and two 300-watt floodlights were hung from a line stretched about 6 m (20 ft) above the river. Visual observations were performed from a spruce tree with a viewing station about 13.5 (45 ft) above the river. The water at the upstream site averaged 0.6 m (2 ft) in depth.

The ensonified area was directly illuminated and observed on two nights. A waterproof 250,000-candlepower spotlight powered by a 12-volt lead-cell battery pack was placed on a pipe driven into the bottom of the river. The spotlight was positioned close to the bottom of the river in water about 1.5 (5 ft) deep. The beam of light was directed across the bottom of the river, aimed at the end of the 12-m (40 ft) barrier section (Figure 7). The behavior and position of each steelhead passing through the ensonified area was described in a notebook. A number was assigned to each observation and was marked near the corresponding target on the sonar graph.

Fall Radio Tagging

Eleven steelhead were caught on sport tackle between November 11, 1989 and December 8, 1989, esophageally implanted with radio tags, and released (Appendix A1). The transmitters (radio tags) were manufactured by Advanced Telemetry Systems and transmitted on discrete frequencies between 30 and 31 megahertz. The two-stage transmitter weighed approximately 20 grams (0.7 oz), was 6.5 cm long by 2.0 cm wide (3 x 1 in.), and had an antenna 30.0 cm (12 in.) long, which extended out of the fish's mouth. Steelhead were held in a plastic tub of water 1 m (39 in.) long, 30 cm (12 in.) wide, and 30 cm (12 in.) deep while the tags were inserted. The fish were released into quiet water after tagging.

Radio-tagged steelhead were tracked about every two weeks over the winter from a Cessna 185 wheel plane at an altitude of about 300 m (1,000 ft). Radio tag

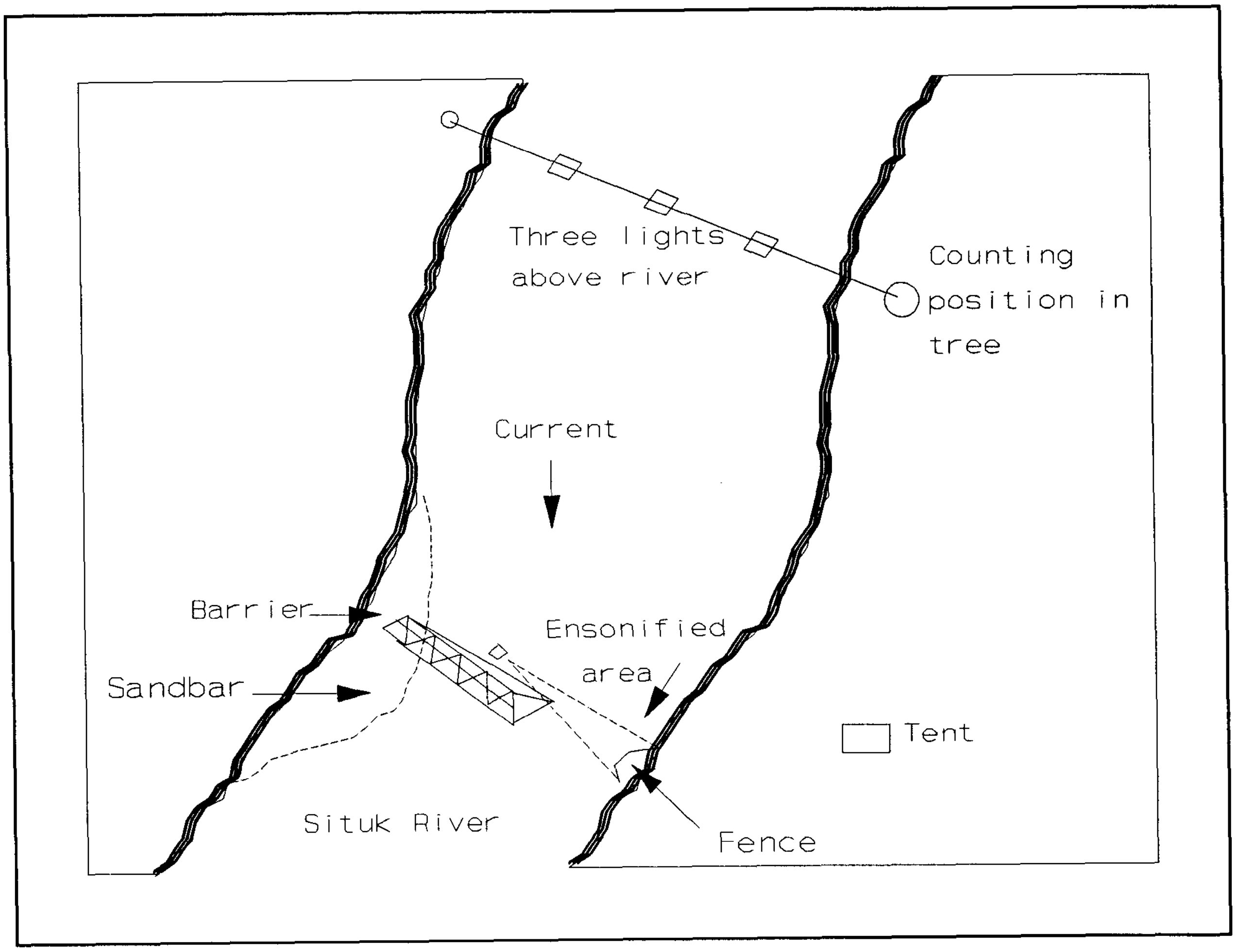

Figure 6. Final configuration of the sonar site with the lights in the upstream position, 1990.

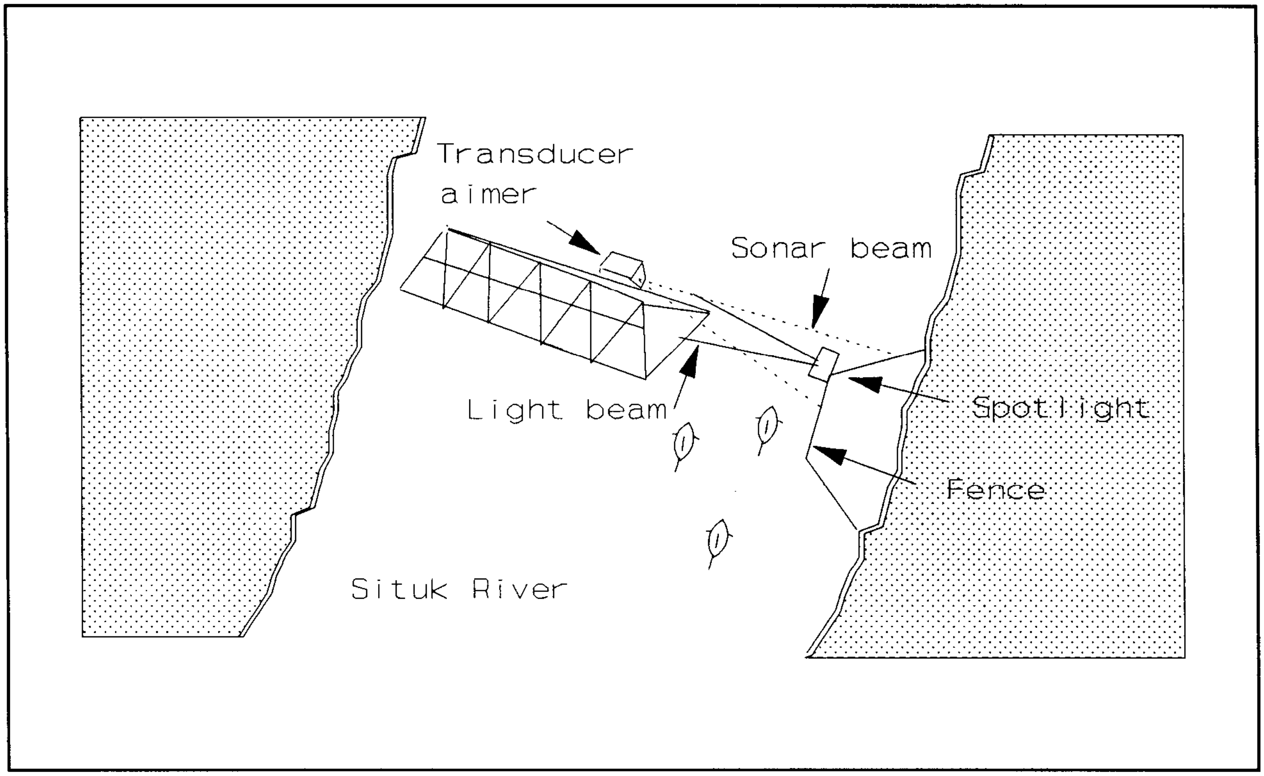

Figure 7. Configuration of the sonar site with the underwater spotlight.

frequencies were scanned with an Advanced Telemetry Systems model R2000 receiver during the flights. The location of the strongest radio signal on each frequency was marked on a map by the operator. That particular frequency was then deleted from the receiver. Several surveys were also conducted from a small boat.

RESULTS

The first 1990 immigrant steelhead to the Situk River was observed on March 16 at 1630 hours. Lights were installed, and visual observations were begun that evening, but no more steelhead were observed until the next night. The sonar was operational on March 18 at 1900 hours.

Visual counts were conducted each night except for a five-day period of flooding that began on March 27. Visual observations were conducted for 12 hours during the flood, but no steelhead were seen. There were few steelhead immigrating as the flood subsided, and those steelhead that were observed were not recorded consistently by the sonar. As the water became lower and cleared, it was obvious that the high flow had scoured a channel at the end of the deep water weir section that could not be ensonified (Figure 8). The weir sections were moved downstream approximately 18 m (20 yds) on April 17 to an unscoured site with a bottom contour resembling the original (Figure 4).

Beginning April 8, sea lions *Eumetopias jubata* began to arrive soon after dark, swimming through the lights and above the sonar site. Sonar recordings were frequently disrupted until the sea lions passed downstream of the site, due to the bubbles, turbulence, and dislodged debris they produced upstream of the site. No immigrating steelhead were observed after sea lions passed upstream.

Adverse reaction to lights by steelhead prompted moving the lights to upstream of the sonar site on April 24. This configuration allowed steelhead to pass through the sonar beam before they were disturbed by the lights. The shallower water at the upstream observation site also allowed more accurate visual counts. Steelhead occasionally refused to enter the lighted area and held between the sonar and the lights. It was important to monitor the position of these downstream fish to avoid duplicate counts.

All of the steelhead that were implanted with radio transmitters during 1989 migrated to Situk Lake (Appendix A2). The radio-implanted steelhead remained in the lake until the survey of May 4. Several transmitters were located in Situk River during that survey, suggesting that migration to spawning areas had begun. It would soon become impossible, using the sonar, to distinguish immigrating steelhead that had temporarily reversed direction from emigrating kelts. The ADFG Division of Commercial Fisheries weir was installed on May 5, and sonar counting was discontinued on that date.

Behavioral Observations

Steelhead generally entered the lower part of the Situk River (near the U.S. Forest Service weir cabin) in schools near the peak of high tides. The steelhead then typically separated into smaller schools (6 fish or fewer) as they began travelling up the next 2 km (1.6 mi) of the river, generally during periods of darkness. Larger schools of steelhead were again observed as they migrated in the river above tidal influence.

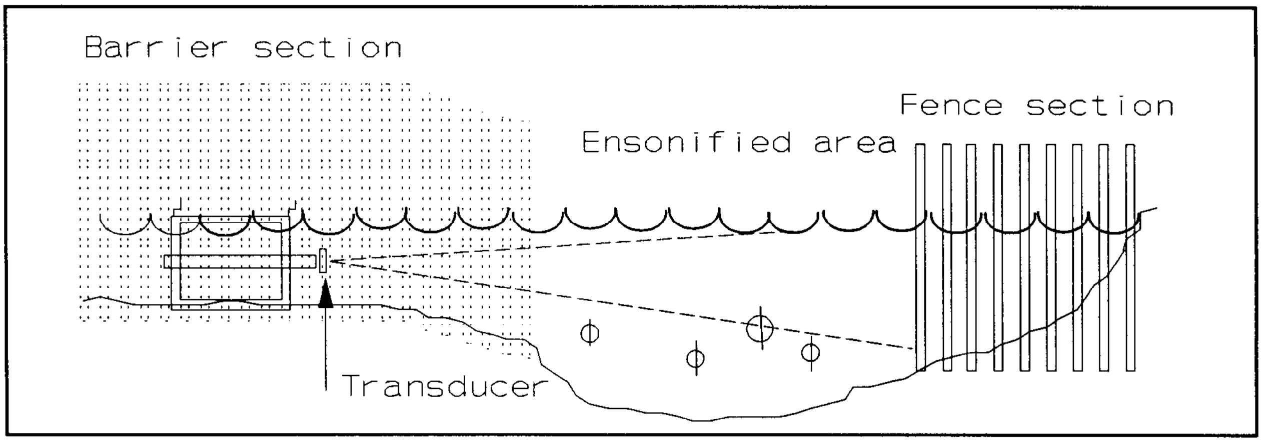

Figure 8. Configuration of the barrier section and stream bottom after the flood subsided.

Most steelhead immigration occurred between 2000 and 2400 hours regardless of the tidal stage, as noted during 1989. There was a lesser, but predictable period of movement near daily high tides. Darkness seemed to be the primary factor influencing steelhead movement in the Situk River. Steelhead arrived at the sonar site correspondingly later in the evening during the lengthened days of spring.

Steelhead that swam through the sonar beam undisturbed, provided the strongest sonar targets (Figure 9, target recordings a, b, c, e). They generally travelled off the bottom, in a straighter path, and at a slower speed, which caused them to remain in the beam in a better location for a longer period.

While undisturbed steelhead provided the most reliable sonar recording opportunities, they continued to be the most difficult to confirm visually during periods of darkness. Lighting allowed visual counts and observations at night, but it also modified fish behavior. This modified behavior varied from rapid and unpredictable movement within the river to holding behavior (sometimes for several hours) beneath the floodlights. Both reactions sometimes made it difficult to obtain accurate counts of steelhead. When holding behavior under the lights caused migration activity to cease, the floodlights were turned off for approximately five minutes. A number of targets corresponding to the number of steelhead holding beneath the lights would appear on the sonar screen shortly after the lights were extinguished.

Identical lighting conditions produced a wide range of responses from individual steelhead. While some steelhead were apparently indifferent to the lights, nearly half of the fish exhibited behavior modification upon entering the lighted area. At times, the only effect of lights on steelhead behavior was faster and deeper travel along the bottom. They would occasionally swim rapidly from one side of the river to the other, up into the unlit area and then back down into the light, or down through the lighted area. It was important that the lights remain stationary, regardless of intensity, to minimize negative responses in the

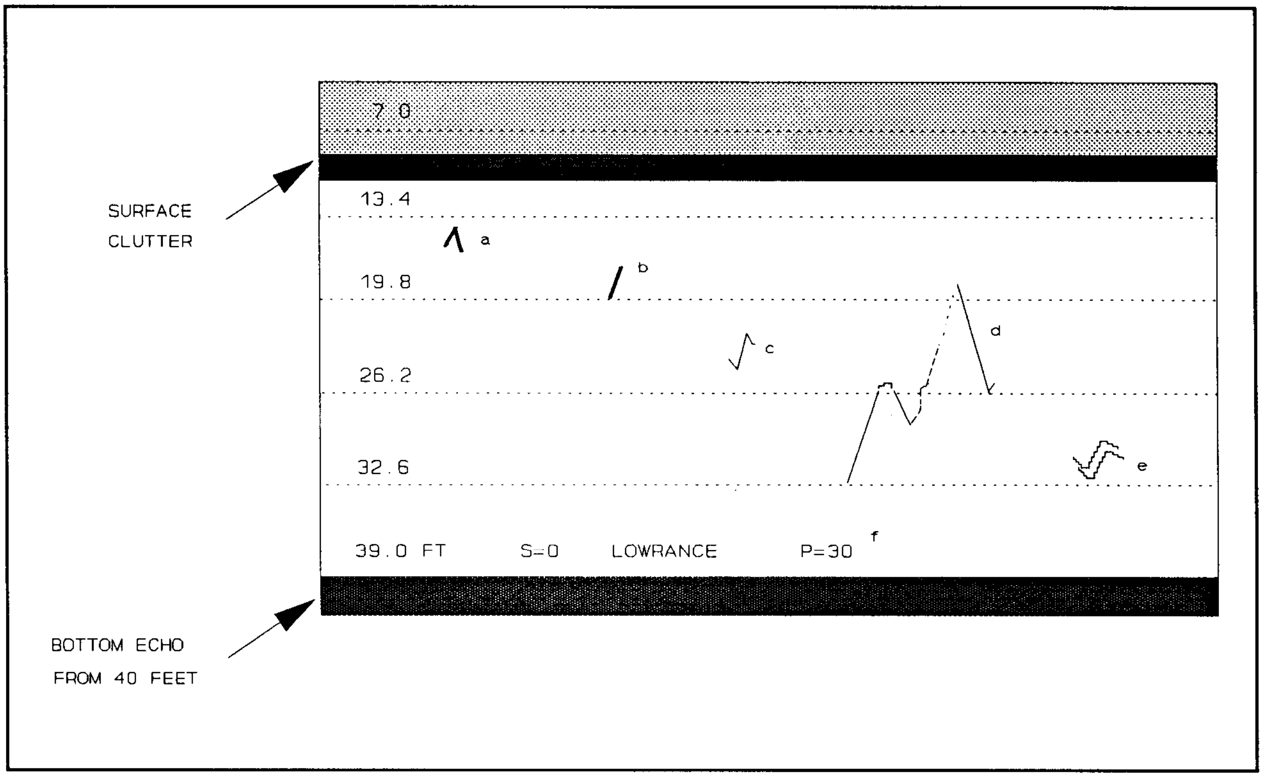

Figure 9. Representative target recordings and features of a sonar graph; ***f*** (bottom line) denotes the information band that prints on the recording paper. In this example, surface clutter (S) is zero, and the pulse length (P) is 30 micro-seconds. Recording ***a*** was made by one steelhead passing upstream approximately 4.5 m (15 ft) from the transducer, turning away from the weir section; recording ***b*** from one steelhead swimming upstream approximately 6 m (20 ft) from the transducer; recording ***c*** from one steelhead swimming upstream approximately 7.2 m (24 ft) from the transducer; recording ***d*** from one steelhead ranging back and forth across the river, in a general upstream direction; recording ***e*** from two steelhead swimming together approximately 9 m (30 ft) from the transducer.

passing steelhead. Sonar targets produced by steelhead were more erratic and less distinct when the lights were in operation (Figure 9, target recording d).

Steelhead Population Size

Except during the period from April 1 through April 17, simultaneous visual and sonar counts produced similar (±15%) results (Table 2). During April 1 through April 17, only 25 steelhead were recorded by the sonar, while 76 steelhead were observed visually. Scouring of the stream channel had obviously affected precision. After the barrier sections were moved downstream and the lights were moved upstream of the site, 310 steelhead were recorded by the sonar, and 353 steelhead were observed visually (88% agreement) during 60 hours of simultaneous observation (April 18 through May 8).

The minimum number of 1990 immigrant spring steelhead was estimated by adding the numbers of steelhead observed during sonar-only operations (1,331 fish), the numbers of steelhead observed during visual-only operations (491 fish), and the greater of the numbers of steelhead counted by either method during periods of simultaneous counting (442 fish). There were also 741 steelhead counted upstream through the Situk River Weir from May 8 through July 25, 1990 (Keith Weiland, Alaska Department of Fish and Game, Yakutat, personal communication). Thus, the minimum number of steelhead immigrating to the Situk River in 1990 was estimated to be 3,005.

DISCUSSION

I believe that the estimate of 3,005 spring steelhead (not including 19 weir kelt mortalities and an estimated sport harvest of 233 steelhead) returning to the Situk River during 1990 is accurate. I do not know how many steelhead passed the site undetected during the flood of March 27-March 31, but it was sufficiently early in the run that few steelhead were probably missed. Steelhead did not immigrate each night after sea lions entered the river, so few steelhead would have been missed when sea lion activity disrupted the sonar.

By July 25, 3,630 steelhead had passed downstream through the Division of Commercial Fisheries weir (Keith Weiland, Alaska Department of Fish and Game, Yakutat, personal communication). Based on angler surveys, the 1990 spring sport steelhead harvest was 321 fish (Johnson and Marshall, *In press*). Adding the weir steelhead kelt mortalities (19), downstream weir steelhead counts, and the total sport harvest produces a minimum estimate of the total (spring 1990 plus fall 1989) steelhead run to the Situk River of 3,970 fish. This estimate is also a minimum because it includes an unknown number of natural and fishing mortalities.

The overwintering fall component of the Situk River steelhead has been assumed to be smaller than the spring component. The estimated size of the 1989 fall run from this study is at least 644 steelhead (3,630 + 19 − 3,005). The 321 steelhead harvested during the spring sport fishery could not be attributed to either run, so they were omitted from the estimate.

Effectiveness of Sonar

Substantial operator support was required to conduct the sonar counting operation. Precise placement and aim of the sonar beam, angled through an ensonified corridor where steelhead passage was confined, was necessary to record

Table 2. Numbers of immigrant steelhead counted by sonar and by visual observation, and numbers of hours counted, in the Situk River, 1990.

Dates	Type of count[a]	Sonar Hours	Sonar Count	Visual Hours	Visual Count	Hours of no counts[b]	Percent relative count error[c]
3/16 - 3/26	S/V	108	0	41	5	75	
	SV	40	11	40	13		15%
3/27 - 3/31[d]	S/V	78	0	12	0	30	
	SV						
4/1 - 4/17	S/V	204	83	39	392	117	
	SV	48	25	48	76		67%
4/18 - 5/08	S/V	366	1,248	14	94	64	
	SV	60	310	60	353		12%

[a] S/V = sonar counts only, visual counts only, or no counts of either type; SV = simultaneous visual and sonar counts.

[b] Hours of no counts generally occurred during periods when little movement of steelhead had been observed.

[c] Percent relative counting error = $\frac{\text{(Visual - Sonar)}}{\text{Visual}} * 100$

[d] Flood from 3/27 through 3/31; no visual counts possible during this period. No steelhead were recorded by the sonar.

passing steelhead. Side-lobe interference, improper equipment configuration, floods, and other environmental phenomena also permitted steelhead to pass the site undetected. These problems constantly required operator attention, and precluded operation of the sonar as a fully automated system to count steelhead.

While this application of sonar was not reliable under all circumstances, it did work well (with considerable operator support) during most periods. The 88% agreement achieved this season is not directly comparable to the 98% agreement noted last season. The 98% figure from last season was the best correlation obtained during the season during a shorter (10.5-hour) period of observation. The 88% figure reported this year is the average of 60 hours of simultaneous observations during a variety of conditions.

With the proper site and sonar configuration, accurate counts of undisturbed fish travelling off the bottom, in mid-channel, and at a moderate speed are possible. There is potential for the use of this system to count immigrating steelhead under controlled conditions.

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APPENDIX A

Appendix A1. Data for steelhead implanted with radio tags during 1989, Situk River, Alaska.

Radio Frequency	Comments
31.317	Approximately 4.5 kg (10 lb) female with a slight red hue. The anterior dorsal fin ray was scarred. Slight bleeding from the hook wound. Tagged 90 m (100 yd) below the Old Situk confluence (river-mile 11.2) on November 11, 1989. Tag was recovered on May 16, 1990, 180 km (200 yd) below Situk Lake (river-mile 19.9).
31.028	Approximately 7.5 (17 lb) bright male. No wounds, quick recovery from tagging. Tagged just below the Old Situk confluence on November 12, 1989. Was last located on May 16, 1990 at river-mile 18.
31.079	Approximately 4.5 kg (10 lb) bright female. No wounds. Good recovery from tagging. Tagged at the Old Situk confluence on November 12, 1989. Passed down through the weir on June 5, 1990.
31.019	Approximately 6 kg (13 lb) bright female. Hooking wound from pulled eye muscle. Tagged at the Old Situk confluence on November 12, 1989. Was last located on May 16, 1990 at river-mile 16.
31.188	Approximately 5.4 kg (12 lb) male, slightly colored with no scars. Quick recovery. Tagged 270 m (300 yd) above the Old Situk confluence on november 13, 1989. Was last located on May 16, 1990 at river-mile 18.5.
31.290	Approximately 6 kg (13 lb) bright male. Slight bleeding, but recovered quickly. Tagged at the Old Situk confluence on November 15, 1989. Passed through the weir on June 1, 1990.
31.300	Approximately 4.5 kg (10 lb) slightly colored male. Good recovery from tagging. Tagged 135 m (150 yd) below Old Situk confluence on November 16, 1989. Was last located on April 18, 1990 in Situk Lake.
30.989	Approximately 4.5 kg (10 lb) bright female. Good recovery from tagging. Tagged 400 m (440 yd) below the Old Situk confluence on November 16, 1989. Recovered at the weir May 28, 1990.
30.501	Approximately 6.75 kg (15 lb) bright male. Good recovery from tagging. Tagged at the Old Situk confluence on December 8, 1989. Was last located on May 16 1990, at river-mile 11.8.
31.150	Approximately 6.75 kg (15 lb) slightly colored male. Scratches along back. Ventral caudal fin worn. Good recovery from tagging. Tagged at the Old Situk confluence on December 8, 1989. Passed down through the weir on May 25, 1990 at 2300 hrs.
30.311	Approximately 3.6 kg (8 lb) female. Good recovery from tagging. Tagged at the Old Situk confluence on December 8, 1989. Passed down through the weir on May 28, 1990.

Appendix A2. Radio tagged steelhead location (river mile) by date, Situk River, 1989-1990.

Date	Survey Method	Tag Frequency and Location During Survey					
		31.317	31.028	31.079	31.019	31.188	31.290
11/12/89	Boat	11.8	11.8	11.8			
11/13/89	Boat						12.0
11/15/89	Boat	13.0	12.0			14.5	11.8
11/21/89	Air	13.7	12.2		15.0	13.5	14.0
11/27/89	Air	20.0	16.3	SL[a]	SL	SL	20.0
12/11/89	Air	20.0	19.0	SL	SL	SL	SL
12/26/89	Air	SL	19.2	SL	SL	SL	SL
01/12/90	Air	SL	19.2	SL	SL	SL	SL
02/14/90	Air	SL	SL	SL	SL	SL	SL
02/28/90	Air	SL	SL	SL	SL	SL	SL
03/15/90	Air	SL	SL	SL	SL	SL	SL
03/31/90	Air	SL	SL	SL	SL	SL	SL
04/10/90	Air	SL	SL	SL	SL	SL	SL
04/18/90	Air	SL	SL	SL	SL	SL	SL
04/10/90	Air	SL	SL	SL	SL	SL	SL
04/18/90	Air	SL	SL	SL	SL	SL	SL
05/04/90	Boat	SL				19.0	18.0
05/16/90	Air	20.8	18.0	18.5	16.0	18.5	15.8
06/04/90	Weir			1.5			

-continued-

Appendix A2. (Page 2 of 2).

Date	Survey Method	Tag Frequency and Location During Survey				
		31.300	30.989	30.501	31.150	30.311
11/21/89	Boat	13.0	11.8			
11/27/89	Air	SL	15.7			
12/08/89	Boat			11.8	11.8	11.8
12/11/89	Air	SL	16.4		12	11.8
12/26/89	Air	SL	SL	13	12.7	SL
01/12/90	Air	SL	SL	SL	SL	SL
02/14/90	Air	SL	SL	SL	SL	SL
02/28/90	Air	SL	SL	SL	SL	SL
03/15/90	Air	SL	SL	SL	SL	SL
03/31/90	Air	SL	SL	SL	SL	SL
04/10/90	Air	SL	SL	SL	SL	SL
04/18/90	Air	SL	SL	SL	SL	SL
05/07/90	Boat		20.0		20.0	15.0
05/17/90	Boat		10.5	11.8	11.0	
05/25/90	Weir				1.5	
05/28/90	Weir		1.5			1.5

[a] SL = Situk Lake